## 901-50 Non-doppler Three Dimensional Flow Images Obtained via Reconstruction from 2D Vector Velocity Maps

Joseph Kisslo, Laurence N. Bohs, Kathryn R. Nightengale, Gregg E. Trahey. *Duke University, Durham, NC*

We describe a method for producing three dimensional images of flow magnitude and direction. The method involves the use of an ultrasonic vector velocity speckle tracking system which computes 2D flow velocity maps in real time. This system, unlike current Doppler instrumentation, quantifies both the axial and lateral components of flow velocity vectors and thereby requires no angle correction. Numerous velocity maps are obtained for successive, closely spaced parallel planes by translating the ultrasound transducer across the flow region of interest. These 2D velocity maps are processed via commercial graphics software to yield three dimensional images showing the magnitudes and directions of flow throughout the interrogated volume. We present images from *in vitro* experiments with a jet phantom and a 4 mm vessel surrounded by tissue mimicking material. Constant-velocity surfaces obtained from the jet phantom allow visualization of the characteristic high velocity central core, surrounded by cones of lower velocities farther from the jet centerline. Directional arrows superimposed on images of the 4 mm vessel allow visualization of the three dimensional flow velocity profile. Results indicate the promise of this technique for improved visualization and absolute quantification of cardiac flow in an angle independent fashion.

## ECHOCARDIOGRAPHY — TRANSESOPHAGEAL IMAGING/DOPPLER

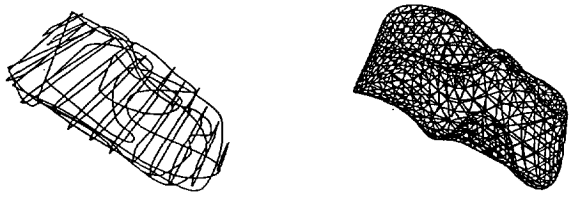
## 901-51 Three Dimensional Reconstruction Using a New Dual Axis Multiplane Transesophageal Echo Probe: Calculation of Left Ventricular Volume

Malcolm E. Legget, Roy W. Martin, Florence H. Sheehan, Gerry Bashein, Edward L. Bolson, Xian-Ning Li, John A. McDonald, Ram Hatangadi, Catherine M. Otto. *University of Washington, Seattle, WA*

The purpose of this study is to validate LV volume measurements using a new transesophageal echo (TEE) probe for 3 dimensional (3D) imaging which allows multiple intersecting "fan-like" scans of the heart to be obtained from a single scanning position. The transducer can be tilted (±30°), and rotated (0°–104°), without moving the probe's tip. A locator system, with a magnetic sensor in the probe's tip, tracks movement in three x, y, and z axes. A customized computer system directly digitizes echo images, and endocardial borders are manually traced and applied to a surface reconstruction algorithm. Scans of 6 excised canine left ventricles have been initially performed. Volumes computed from the 3D reconstructions compared to true volumes are shown below. The regression equation was 3d volume = 0.82 true volume +0.6, $r^2 = 0.95$, $p = 0.01$.

| LV no. | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| True vol (ml) | 30.3 | 23.0 | 24.0 | 27.5 | 60.5 | 28.8 |
| 3D vol (ml) | 30.3 | 18.3 | 19.2 | 23.7 | 49.5 | 21.2 |

The underestimation of LV volumes with these preliminary results may be due to inaccuracies related to the probe, the reconstruction algorithm, and ultrasound beam width. An example of intersecting LV endocardial borders and a wireframe reconstruction are shown:



*Conclusions:* Dual axis multiplane transesophageal scanning enables: acquisition of multiple intersecting scans from a single probe position, 3D reconstruction of the LV, and calculation of the volume.

## 901-52 Ultrasonic Integrated Backscatter Cyclic Variations During Atrial Pacing in Patients with and without Coronary Artery Disease

Leonarda Galiuto, Venanzio F. Napoli, Cataldo Memmola, Vito Marangelli, Sabino Iliceto, Paolo Rizzon. *Cardiology, Bari Univ., Italy*

Contraction and relaxation of normal myocardium are associated with parallel integrated backscatter cyclic variations (IB CV). It has been demonstrated that IB CV are reversibly reduced in magnitude during coronary occlusion and reperfusion. To evaluate in humans the effects of pacing-induced ischemia on IB CV, 29 pts were studied with multiplane TEE and simultaneous atrial pacing (up to 150 beats/m'). A prototype (Hewlett-Packard AD system) was used to acquire and analyse IB images. In each pt a transgastric 2 chamber view was acquired at rest, at peak-pacing and 5 cardiac cycles after pacing interruption (recovery). Twenty-one pts had significant coronary stenosis (≥50% narrowing): 8 pts developed myocardial ischemia (chest pain, ECG changes and wall motion abnormalities) during atrial-pacing [Group A], while the remaining 13 pts did not [Group B]. Eight pts had normal coronaries and no myocardial ischemia during pacing [Group C]. IB CV analysis was performed only in myocardial segments perpendicular to ultrasonic beam (anterior and inferior wall in transgastric view). In group A and B pts only segments within a territory supplied by a stenotic coronary artery were considered. *Results:*

IB CV are expressed in decibel units

| | Rest | Peak-pacing | Recovery |
|---|---|---|---|
| Group A | 7.3 ± 2.7 | 5.1 ± 1.7 | 6.7 ± 2.8 |
| (15 segments) | $p < 0.01$ | $p = ns$ | |
| Group B | 6.5 ± 1.3 | 5.1 ± 1.7 | 6.2 ± 2.1 |
| (23 segments) | $p < 0.002$ | $p < 0.02$ | |
| Group C | 7.8 ± 2.2 | 7.7 ± 1.8 | 7.5 ± 1.6 |
| (18 segments) | $p = ns$ | $p = ns$ | |

*Conclusion:* atrial pacing does not affect IB CV in myocardium supplied by normal coronary arteries. During pacing, IB CV are blunted in myocardium supplied by significantly narrowed coronary arteries, even in the absence of traditional signs of ischemia. IB CV have a potential in the identification of stress-induced regional left ventricular dysfunction in pts with coronary artery disease.

## 901-53 Right-to-Left Shunts in Patients with Severe Hypoxemia: Transesophageal Contrast Echocardiography Study

Steve S. Lin, Jae K. Oh, A. Jamil Tajik, Peter C. Gay, Yehezkiel Kishon, James B. Seward. *Mayo Clinic, Rochester, MN*

Severe hypoxemia due to right-to-left (R-to-L) shunt has been well-documented in isolated case reports. Several mechanisms of R-to-L interatrial shunt in hypoxic patients have been identified. Although less-well recognized, R-to-L intrapulmonary shunts have also been demonstrated on contrast echocardiography in patients presenting with hypoxemia. Transesophageal contrast echocardiography (TEE) has been established as a sensitive tool in the diagnosis of R-to-L interatrial or intrapulmonary shunts, however, the utility of TEE in the evaluation and outcome has not been studied. We reviewed medical records of 45 consecutive inpatients with hypoxemia as an indication for echocardiographic examination from 1989 to 1993 and assessed the clinical impact of TEE. All had chief complaint of dyspnea and baseline hypoxemia (room air pO2 less than 76 mmHg). The etiology of hypoxemia could not be determined following history, physical examination, and initial evaluation. Transthoracic (TTE) and transesophageal echocardiography were performed for suspected R-to-L shunt. There were 26 males and 19 females. Mean age was 56 ± 13. In 5 patients, TTE suggested R-to-L interatrial shunt. TEE findings were as follow: 35 interatrial shunts, 7 intrapulmonary shunts, 4 pulmonary embolisms (PE), and 1 superior vena cava-to-pulmonary venous (SVC-to-PV) shunt. Of those, 15 patients had recommendations for significant therapeutic change following TEE; medical treatment for PE in 4, interatrial shunt repair in 9, 1 intrapulmonary shunt repair, and 1 SVC-PV surgical repair. All patients with R-to-L interatrial shunts were associated with processes known to cause right heart pressure overload. The three most common associations in patients with R-to-L interatrial shunt were pulmonary embolism (10), COPD (7), and pulmonary fibrosis (5). The 7 intrapulmonary shunts were noted with hepatic cirrhosis (3), pulmonary fibrosis (2), and primary pulmonary hypertension (2). All patients except one improved symptomatically during subsequent follow-ups. *Conclusion:* Clinically significant hypoxemia can result from echo contrast detectable R-to-L interatrial or intrapulmonary shunt. In severely hypoxic patients with R-to-L shunt, TEE is the most effective diagnostic modality.

## ECHOCARDIOGRAPHY — TRANSTHORACIC IMAGING/DOPPLER

## 901-54 Exercise Echocardiography is More Cost Efficient than Exercise ECG as an Initial Test for Evaluation of Cardiac Symptoms in Women

Terry Anderson, Thomas Marwick, M. John Williams, Brian Haluska, Fredric Pashkow, James D. Thomas. *Cleveland Clinic Foundation, Cleveland, OH*

Although exercise echo (ExE) has been shown to be more accurate and spe-